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THE FIRE-FLIES AND THEIR PHOSPHORESCENT PHENOMENA.

BY MRS. V. O. KING.

THE most interesting feature distinguishing these insects is their phosphorescent qualities. Light, so universal in its influences upon the life processes, and made familiar to us through the multiform media of its evolution, is known to result from a combustion of dead matter. To this known fact, *Lampyrus*, creeping and flying, and at the same time emitting light, would seem to present a contradiction.

This singular fact early attracted the attention of naturalists and philosophers. A traveler in Japan, about the middle of the 15th century, studied its phenomena, discovering two kinds of light; and later, Mr. McCartney, by anatomical investigation, found two vesicles from which he supposed the more permanent light to proceed. Similar discoveries were made about the same time by a Polish naturalist. Many distinguished entomologists have given attention to the subject; even Arago studied the character of the light in connection with that of the sun, and found it to exhibit the same species of refrangibility with the light of that body.¹

Matteucci, who studied this phenomenon from a chemical standpoint, concluded that there was positively no phosphorus present in the luminous segments, and therefore accounted for the manifestation by other means.

Prof. Pancerri of Naples, a few years since, concluded that phosphorescence in animals is the result of oxidation of certain fatty material, composed partly of epithelial cells in a state of partial decomposition, a manifestation (as Draper also says) of dead matter only; due to a slow combustion by which vibrations are excited capable of transmitting luminous rays. This phosphorescent substance, Pancerri finds secreted in glands in all cases except noctulica.

¹ The spectrum given by the light of the common fire-fly of New Hampshire (*Photinus*?) was found by Prof. C. A. Young to be perfectly continuous, without trace of lines either bright or dark. It extends from a little above Fraunhofer's line C in the scarlet, to about F in the blue, gradually fading out at the extremities. This portion is composed of rays which, while they more powerfully than any others affect the organs of vision, produce hardly any thermal or actinic effect; in other words, very little of the energy expended in the flash of the fire-fly is wasted. Prof. C. A. Young in the AMERICAN NATURALIST, Vol. iii, p. 615.—EDITORS.

I have examined many of the Lampyridæ; the phosphorescent segments in the highly organized species contain a translucent substance resembling half-cooked starch, situated just behind a yellow waxy-looking membrane. This membrane has, on its ventral aspect four distinct spiracles for the admission of air.

Through these spiracles and contiguous parts may be seen at times quick brilliant flashes of light, made more rapid and vivid when the insect is handled, and followed in its normal state by a milder emanation, which may be compared to the embers of the previous conflagration. This second light is yellowish and dies out slowly. The first appearance of fire-flies in the twilight is indicated by a red, followed shortly by yellow, and later by the characteristic green light.

Different species vary in the degree of activity and also somewhat in the manner of emission. The phenomenon is also subject to changes during the metamorphic period.

The larva in *Photinus* emits a steady green light from the posterior segments on the ventral surface. The pupa light, at first green, soon assumes a whiter less brilliant character, diffused over the entire body.

The imago of the apterous female of *Pleotomus* exhibits greater intensity, and over a larger surface than in male forms, but steady, and at times disappearing from the posterior segments to be diffused as a white light over the body. This insect is scarcely more than an egg-bag, and its light is never so green as in other species. There is almost as great a diversity of degree and manner as of varieties, each enabling the observer to identify them at night.

A peculiar odor is perceptible, at times, in fire-flies. An English writer first noticed this, but afterwards concluded that he might have been mistaken.

The soil which is most frequented by glow-worm larvæ consists largely of decomposed rocks, and produces a growth whose ash is intensely sulphurous to the taste. In these places may also be found earth-worms filled with phosphorescent matter, and snails, the favorite food of the glow-worm larvæ, while the *Primula mexicana*, the vegetable diet of adult winged species, also abounds. All these features obtain in a moist soil and open air of fields, where, according to Ebermeyer, ozone is found in greatest quantities, and oxygen its other form.

A calcium sulphuret of phosphorus, prepared by heating sulphur with calcined oyster shells, is said to give out a yellow light when exposed to the sun's rays, but under decomposed light there is a change to green. The decomposition of certain rocks furnishes phosphates of calcium to the soil, whence having been appropriated by plants it eventually supplies animals. When not oxidized in the stomach it is supposed to be absorbed into the system in certain oils. Phosphorus in its active state ignites spontaneously in contact with the air.

In *Lampyrus* we see changes identical with those presented by a calcium sulphuret of phosphorus from the red or yellow to green.

The emission of the greatest amount of light would also point to the presence of phosphorus, this occurring most freely in the open air, and when the insect is either flying or excited, when the body is presumed to be most fully inflated with air, the spiracles on the luminous segments being very favorable for its admission.

The second light, referred to as of a milder kind and with a steadier emanation, would seem to be portions absorbed by the translucent substance during the more active evolution of light, and reflected from the less permeable inner face of the dorsum until exhausted.

The uses of the light of *Lampyrus* seem as doubtful as its nature. As it cannot be of service in the larval state either for sexual attraction or to secure food, its presence at this early period must be for the benefit of succeeding stages, and especially for the imago in the case of the apterous female.

The periodicity of the phenomenon may be ascribed to that property of the ganglia which enables them to give a periodical exhibition of an original disturbing cause.

There is a definite relation between the proportion of light emitted, and the color of the enclosing membrane which indicates the former's bleaching power.

Draper illustrating a truth says, that "not a shadow falls for an instant upon a wall but it leaves an ineffaceable stain," thus by his shadows bringing the power of light into bold relief. If a ray of light falls, however softly and but for an instant, upon an object, we may presume that a change, whether by chemical or mechanical means, ensues. Flowers and fruits by their irregular surfaces break the sunshine into specific hues, thus acting as shadows to themselves. Animals also respond in coloring to the influence of light.

In *Lampyris* the almost perpetual play of light, generated and partly confined within the posterior segments, has probably conduced to their final change of color. Ozone, of whose presence there is a suspicion, possibly exercises its bleaching power here as in vegetable tissues.

Assuming that the phosphorescent material is accumulated in the larval and preserved in the pupal stage for the final form, there are certain ways in which it might be useful at this latter period. The apterous female, being without food, must generate sufficient heat, from internal resources, to sustain life through oviposition.

The winged species may also utilize this power to decoy victims, and also to betray their presence to the carnivorous species, while others may kindle the torch of Hymen by this veritable flame. That both sexes possess phosphorescent properties is not surprising, since both are the product of a luminous stock, but we may expect a greater degree of phosphorescence from the female, and facts sustain this expectation.

Thus our insect seems eminently conservative in its powers, while combining the useful and the beautiful in its physical gifts.

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PHYSIOGRAPHY.

BY C. LLOYD MORGAN, F.G.S., A.R.S.M.

THE artist who is illustrating a great theme upon a large spread of canvas finds it necessary from time to time to lay down the brush, with which he is accurately filling in the more delicate minutiae, that he may retreat to a distance and view his picture as a whole. It is essential to the higher development of his art that he should not omit this comprehensive survey. The same thing holds good in literature and science, as well as in art. The historian must, from time to time, take a fresh survey of history as a whole. If he neglect to do so, the group of figures to which he devotes his special attention will certainly not take up its true position among the other groups that appear on the canvas of history. The man of science, also, should not forget that he is, according to his individual bent or capacity, aiding in the construction of a great philosophy; and he should now and again turn aside from the microscope, or lay down the hammer, to take a